AD A064207

USARTL-TN-32

CH-47 HELICOPTER INTERNAL CARGO LOAD AND RESTRAINT SYSTEM MOCK-UP STUDY

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November 1978

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Prepared for
APPLIED TECHNOLOGY LABORATORY
U. S. ARMY RESEARCH AND TECHNOLOGY LABORATORIES (AVRADCOM)
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER USARTL-TN-32	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) CH-47 HELICOPTER INTERNAL CARGO LOAD AND RESTRAINT SYSTEM MOCK-UP STUDY		5. TYPE OF REPORT & PERIOD COVERED Technical Note Aug[redacted]77 - Nov[redacted]978
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John F. Tansey		8. CONTRACT OR GRANT NUMBER(s) House Task RM-77
9. PERFORMING ORGANIZATION NAME AND ADDRESS Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM) Fort Eustis, Virginia 23604		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE Nov[redacted]78
		13. NUMBER OF PAGES 16
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Helicopters
Cargo
Logistics support
Pallets
Restraint

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A conceptual CH-47 helicopter internal cargo load and restraint system was designed, and a nonflightworthy functional mock-up of the system was constructed. Mock-up components consisted of a rail/roller and support grid, fore-and-aft cargo barriers, and a ball transfer table. The system was tested in a CH-47 and proved to be easily installed without aircraft modification. Ease of use with standard Army warehouse pallets and USAF 463L pallets was demonstrated. It was concluded that the system has potential for maximizing aircraft payload capabilities and over

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Block 20. Abstract - continued.

improving cargo handling procedures significantly. The same technology could also be made applicable to utility helicopters.

PREFACE

In May 1977 the Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), received from the Commander in Chief, U.S. Army, Europe (USAREUR), a request for development of a cargo helicopter internal rapid loading and offloading capability. With funds provided by the CH-47 Modernization Program Manager's office, this laboratory conducted an in-house study as a current first step toward providing the stated capability.

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INTRODUCTION

USAREUR has documented a requirement for a cargo helicopter internal cargo load and restraint system in order to expedite the loading and offloading of high priority throughput palletized supplies. Based on the estimated threat in the European theater, rapid, direct movement from the theater rear to the forward supply and rearming points will dictate helicopter transport with internal loads. One primary concern relates to the emergency resupply of tank-killing units with the TOW and HELLFIRE missiles. U.S. Air Forces Europe (USAFE) has also identified requirements for Army medium lift helicopter movement of not operationally ready supplies (NORS), munitions, and sensitive cargo to fighter bases in the close proximity of the aerial port of debarkation (APOD). The ultimate goal is for the CH-47 helicopter to participate in the USAREUR airline of communications (ALOC).

In order to meet these and other growing requirements, the need exists for a CH-47 internal cargo load and restraint system capability that provides for simplified cargo loading, maximum payload utilization, faster aircraft turnaround time, and improved tactical support.

PROGRAM OBJECTIVE

The general objective of the program was to study the engineering aspects of providing a rapid internal cargo load and restraint system for the CH-47 and to assess the viability and practicability of such a capability. During the course of the program, all previous efforts at providing a similar capability were reviewed. A conceptual, baseline system design was produced to facilitate the loading of standard Army 40- x 48-inch wooden warehouse pallets and Air Force 463L pallets. This nonflightworthy design was then used to build a full-scale functional mock-up in order to demonstrate the technical feasibility and to assist the Army user in determining the desirability for such a system. The mock-up served as a visual aid to stimulate interest as well as to highlight possible engineering problem areas.

PROCEDURES

Initially, a list of desired system design characteristics was prepared to serve as a guideline as the concept(s) evolved. This list was continually updated during the program. The final design criteria, used in this study, prescribe that the system should:

a. Be installed and employed without aircraft structural modification.

b. Accommodate 463L Cargo Delivery System pallets, standard Army warehouse pallets, and the family of munition pallets.

c. Accommodate TOW (58 x 39 x 51 inches) and HELLFIRE (70 x 40 x 34 inches) missile crates.

d. Provide a rapid load and unload capability for bulk cargo.

e. Provide cargo restraint meeting the following criteria:

Forward attenuated - per MIL-STD-1290 (Reference 1)

Aft	5g
Lat	1.5g
Down	4g
Up	2g

f. Protect the aircraft interior, e.g., heating ducts, buffer boards, hydraulic lines, rams and actuators, from cargo-induced damage.

g. Be capable of being installed or removed in less than one-half hour.

h. Allow for minimum interference with wheeled loads.

i. Provide auxiliary support for tail ramp loads in excess of 3,000 pounds but not more than 10,000 pounds.

j. Protect aircraft from loading and ground handling equipment damage.

k. Accommodate troop seats as installed for dual mission capability.

1. Provide for minimum system weight (< 800 lbs) and minimum cost.

These requirements and provisions, although not all represented in the mock-up, would nonetheless be necessary in an actual flightworthy system. For the purpose of simplicity and low cost, the mock-up was to employ only current technology and be constructed of off-the-shelf hardware items.

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[1] Military Standard, MIL-STD-1290(AV), *Light Fixed- and Rotary-Wing Aircraft Crashworthiness*, Department of Defense, Washington, D.C., 25 January 1978.

DESIGN

The mock-up design assembly as shown in Figure 1 consisted of three major components: rail/roller and support grid, fore- and aft-cargo barriers, and a ball transfer table (not shown). The rail/roller and support grid consisted of oak joists supporting steel rails with integral high hysteresis wheels (see Figure 2) which provided quiet, smooth, and efficient transfer of cargo through the aircraft. The oak joists were contoured to seat flush on the aircraft floor. These joists were secured to the aircraft floor at stations 480, 420, 360, 240, and 180 by means of a simple pin through the tie-down fittings located on aircraft butt lines 20 and -20. The outermost rails carry a guide/restraint bar offset by 6 inches. This bar protects the buffer boards and heating ducts from damage, and restrains the cargo in the sideward direction. With a slight design modification, the bar could restrain the 463L pallet in the vertical direction. This bar also generally keeps the cargo properly aligned during loading and transfer. The four rails are placed to provide optimum spacing to receive the standard 40- x 48-inch warehouse pallet and to minimize treadway interference. The grid components were numbered and color-coded for quick and easy assembly and installation.

The fore-and-aft crash barriers shown in Figure 3 secure the bulk cargo as a unitized load in the longitudinal direction against 90th percentile crash survivable loads. The forward barrier would statically restrain loads to a threshold limit of 7g and then by means of a load attenuating device (e.g., honeycomb core crushing, rod and wire bending, tube buckling) deform with controlled deflection with a stroke of 20 inches or more to absorb and dissipate crash impact energy while maintaining a tolerable level of deceleration. The longitudinal positioning of the barriers would necessarily be variable in order to keep the cargo centroid within the center-of-gravity envelope of the aircraft.

The ball transfer table, consisting of two 18-inch-wide rails, extends from the tail ramp threshold across the ramp and 5 feet outboard of the ramp end. Both rails have 1-inch plated steel balls in a staggered 3-inch spaced pattern and are supported outboard by four tripod stands (see Figure 4).

These transfer units allow cargo to be manually moved in any horizontal direction so that cargo pallets may be deposited and then properly aligned before being shoved into the cargo compartment. A 5-foot extension aft of the ramp serves as a buffer to prevent inadvertent aircraft damage caused by ground handling equipment as well as a platform to rotate and align cargo properly prior to loading. The actual system will have provisions capable of supporting aft ramp loads up to 10,000 pounds.

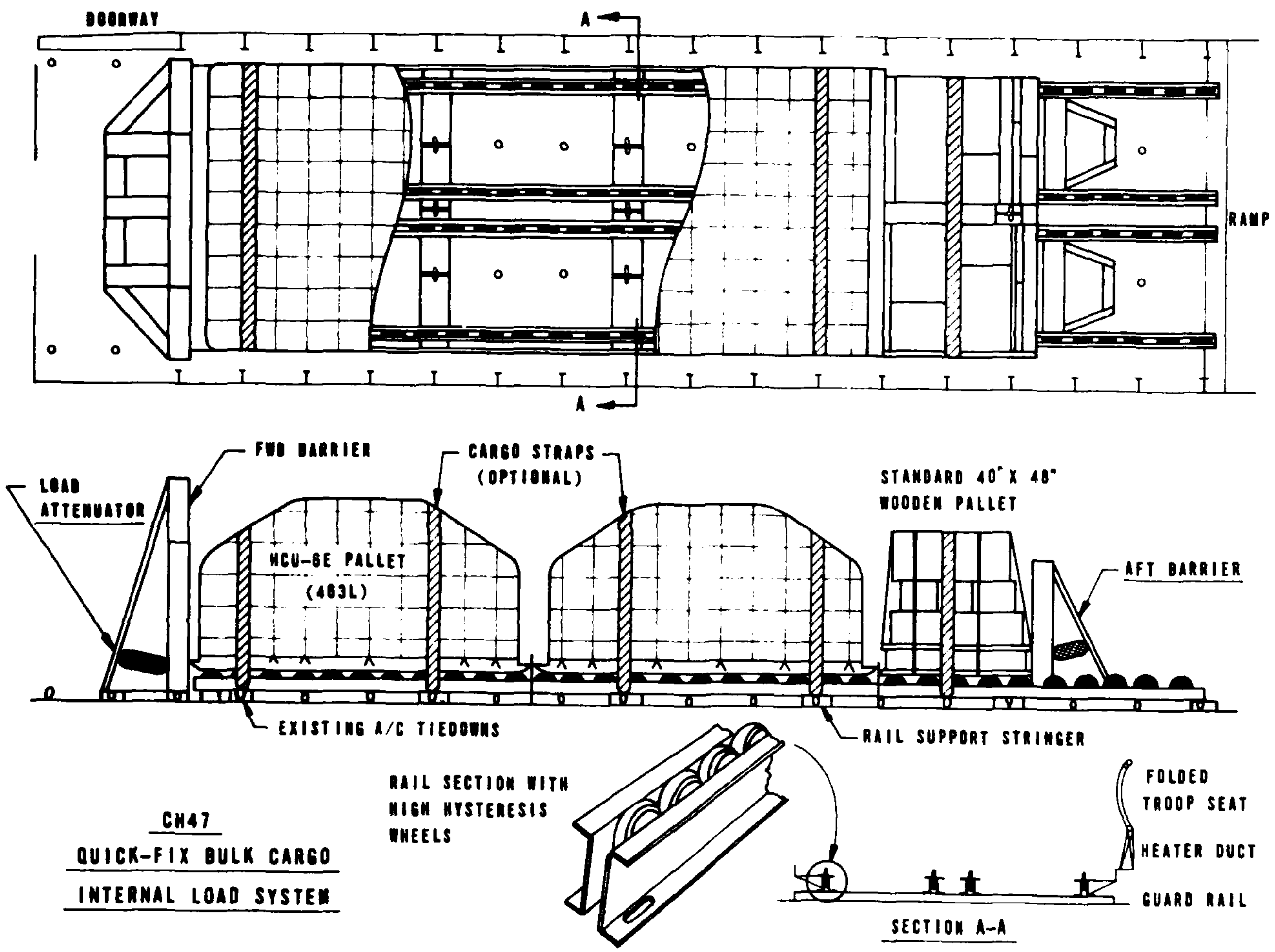

Figure 1. Mock-up design assembly.

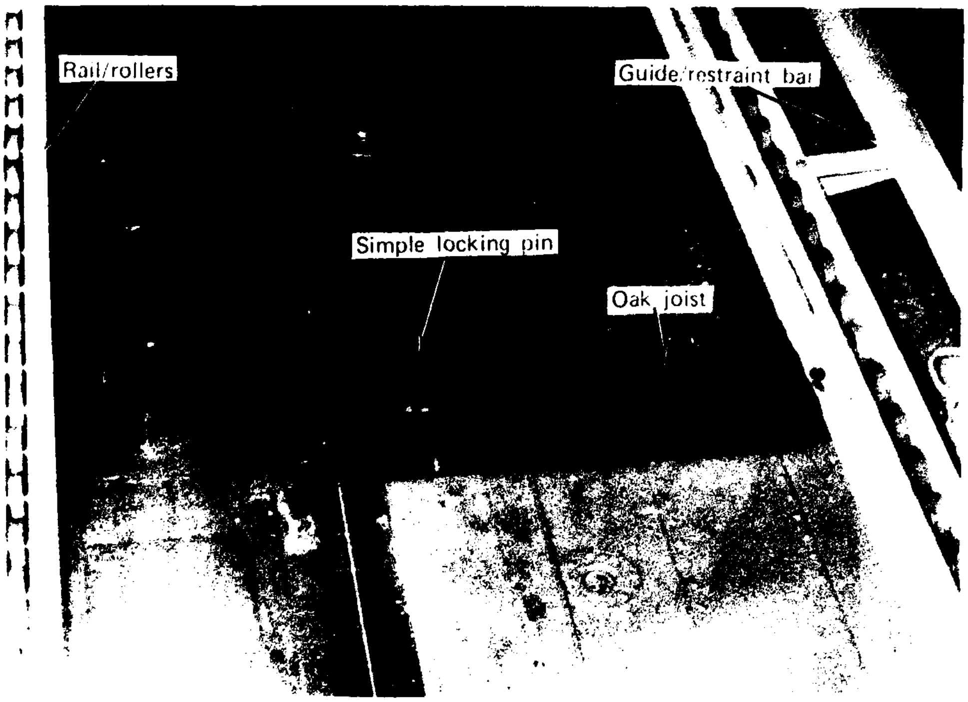

Figure 2. Rail/roller and support grid.

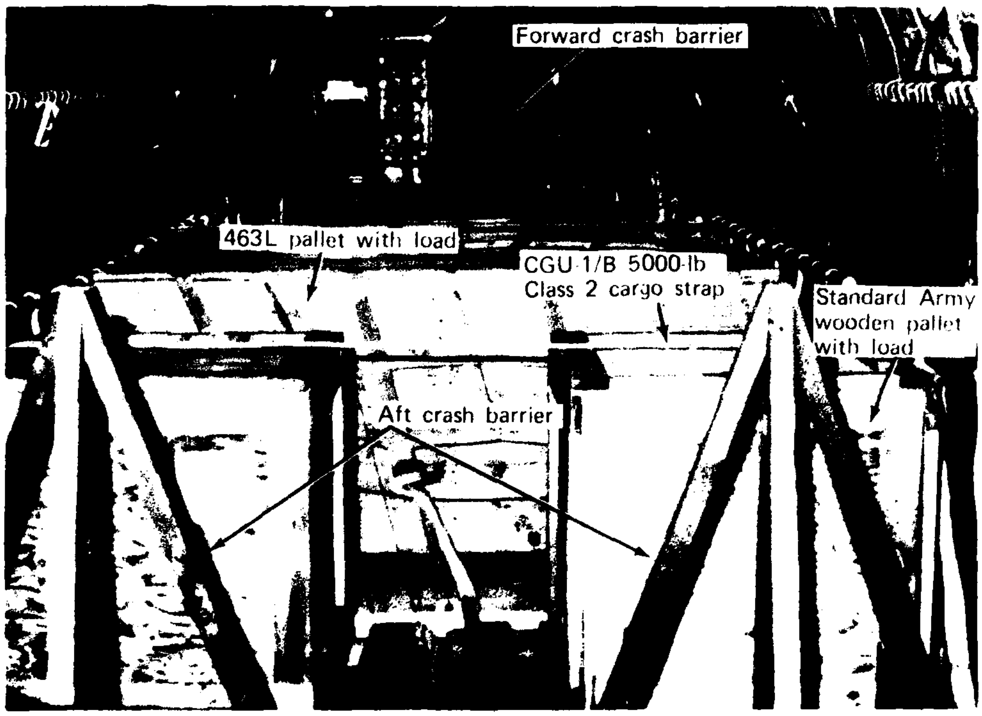

Figure 3. Bulk cargo restrained in the longitudinal direction with fore and aft barriers.

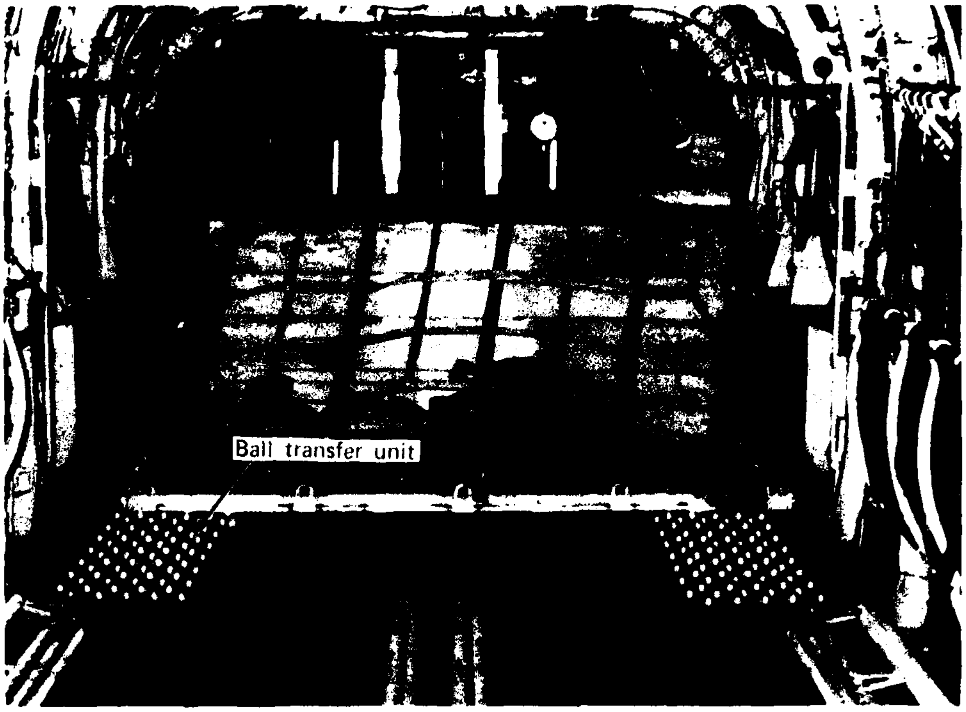

Figure 4. Ball transfer table with 463L pallet.

INSTALLATION

The entire mock-up system was installed in a CH-47 helicopter (see Figure 5) in approximately 30 minutes by four men who were unfamiliar with the hardware. The hardware was both color-coded and stamped with aircraft frame numbers to facilitate location and assembly of the system.

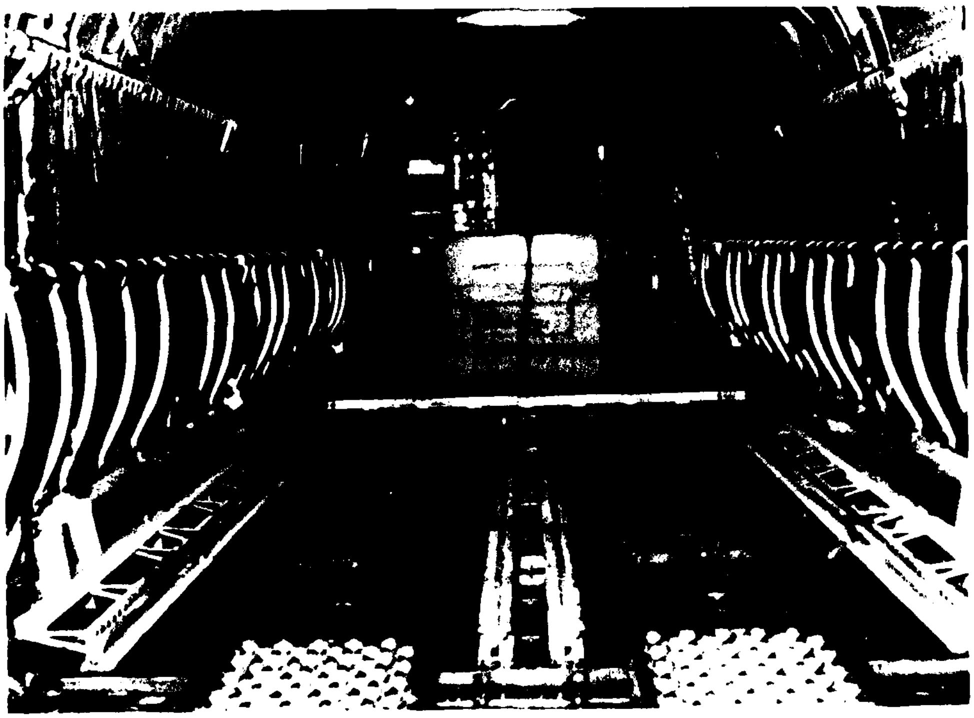

Figure 5. Mock-up internal cargo load and restraint system installed in a CH-47.

TESTING AND DEMONSTRATION

The internal cargo load and restraint system was installed in a CH-47 twice to verify the form and fit qualities of the design. Empy 463L pallets were cycled in and out of the aircraft as a dry run test. After some minor changes and adjustments, the hardware was complete and ready for full-scale testing.

Two 463L (HCU-6/E) pallets were affixed with conservative loads of 2500 and 3000 pounds each. In addition, two standard warehouse pallets were strapped with boxes representing a 4-foot-high load with permissible overhang. The four pallets as described were loaded into a CH-47C and secured with 3/8-inch steel pins through the rails in approximately 20 minutes (see Figure 3). Resources used were a 15,000-pound capacity forklift, a driver, and four cargo handlers.

For safety purposes, all pallets are statically restrained in the longitudinal direction with steel pins, primarily to prevent accidental roll-back. The 463L pallets are restrained vertically by guide bars on either side of the aircraft and the wooden warehouse pallets are restrained vertically by standard CGU-1/B 5000-pound capacity Class 2 cargo tiedown straps (see Figure 3) as needed.

The loading demonstration was witnessed by the CH-47 Program Manager, U.S. Army Training and Doctrine Command representatives, and interested Army agency personnel. This exercise was conducted to help assess the Army's interest in and possible engineering development of a system for the cargo helicopters.

This task has been instrumental in increasing the level of interest toward this program and has highlighted many as yet unanswered questions concerning the engineering and logistics of such a capability. There still remains the question of rail configuration to suit the many pallet sizes used for ammunition, NORS, HELLFIRE and TOW missiles, and other cargos. There are also questions of floor loading, restraint criteria, and load attenuation to be solved through a major design effort. Unresolved risks which result from a lack of data on interfacing operations, type equipment, and type loads encountered in the USAREUR system must be identified and designed for.

CONCLUSIONS

The need to improve the efficiency of the delivery function of the CH-47 has become increasingiy vital. USAREUR and USAFE have identified and documented requirements for a helicopter internal cargo system that maximizes payload capability and is capable of rapid load/unload and restraint of high priority throughput supplies, NORS, munitions, and sensitive cargos, in order to expedite movement and facilitate emergency resupply.

As demonstrated in the CH-47, the system concept, when applied to cargo helicopters, could provide an effective tactical combat service interface with the distributor, and the Military Airlift Command, and bring about participation in the USAREUR airline of communication (ALOC). It is also possible that much of the same technology could be extended to utility helicopters, thereby further utilizing the internal cargo transporting potential inherent in those aircraft. This task demonstrated that applied technology, coupled with innovative engineering, can provide the basis for the development of such a system for helicopters having cargo transport missions. Results also show that the requirement can be met without structural aircraft modification. In light of the demonstrated capability, a cargo system responsive to the user requirement could be made available for evaluation and testing within 14 months of a program start.